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ABSTRACT

The reaction times (RTs) of 48 elementary school students in two word identification tasks were recorded to gauge the effects of orthographic and phonic structures. The subjects, high ability and low ability students from grades four and five and from grades two and three, either matched a word to one of two pictures on display or decided if a visual display of letters made a word. In the picture task, the older and high ability readers had faster RTs. The low ability readers had extreme difficulties with low frequency words, and the meanings of words containing commonly taught phonic units were accessed faster than words lacking such elements. Although there was no main effect of orthography, there was a significant interaction between orthography and frequency. In the word/nonword task, older readers were much more adept than younger readers, but ability was not a significant factor. Apparently exposure to print helped determine "wordness." High frequency words were recognized more rapidly as real words, but to a lesser extent than in the picture condition. These results indicate that phonic structures are the critical factors in word identification, while orthographic redundancy takes a supporting role in the identification of low frequency words. (RL)

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Effects of Orthographic and Phonic Structures on Word Identification

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Word identification is a complex process which involves both the ability of the reader and the nature of the textual material. Much of the contemporary research in reading was stimulated by the seminal work of Cattell (1886) who demonstrated that subjects were able to more accurately report the contents of briefly presented visual displays if they were embedded in words rather than in unrelated strings of letters. Current investigation into the Word Apprehension Effect (WAE) has been instrumental in identifying several cogent elements of word and letter identification as well as stimulating research in the area of contextual effects of word/letter identification (see Reicher, 1969; Krueger, 1975; Smith & Spoehr, 1974).

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Of particular importance to the present study are a large number of perceptual experiments that, in general, show that letter/word identification is dependent on the degree to which the visual display conforms to the regularities of the English language. For example, words high in sequential redundancy are recalled better than those low in redundancy (Miller, Bruner & Postman, 1954; Rumelhart & Siple, 1974). Mason (1975) hypothesized that spatial redundancy (viz. positional frequency) can be used to "augment visual featural information in the identification of individual letters" p. 147. In one experiment she had good and poor sixth grade readers search for the presence or absence of target letters and found that good readers were superior to poor readers only when the target letter was displayed in a highly redundant position.

In addition to orthographic factors influencing letter/word identification, other researchers have demonstrated the influence of phonic structure or "vocal center groups" on letter/word identification (e.g., Spoehr & Smith, 1973; Juel, in press). Thus, two factors have been identified as influencing letter/word identification (orthography and phonic structure). These two factors tend to be related, and in previous research it has been difficult (or impossible) to specify the influence of one independent of the other.

The present experiment was designed to further specify the effects of orthographic and phonic structure on word identification in reading. We were particularly interested in maintaining a reading task. Other reaction time (RT) tasks, using a letter search task have shown effects of orthographic structures (Mason, 1975; Massaro, 1979).

However, it can be argued that letter search task may represent processes not isomorphic to those involved in going from a printed word to its meaning.

Method

The current study consisted of two conditions. In Condition 1 subjects saw a slide of a word and two pictures - one picture was unrelated to the word and one represented its meaning. Subjects pressed a RT time key corresponding to the correct picture. The word varied on three dimensions: Frequency (high or low), decodability (easy or hard phonic patterns), and orthographic redundancy (high or low summed positional frequencies of individual letters). In Condition 2, subjects saw only a word (or a nonword) projected on a screen; the dependent measure was RT in deciding if the visual display of letters made a word or not.

Subjects

A total of 48 children enrolled in a summer reading tutorial program at the University of Texas at Austin, participated in the study. (The program was promoted by the local school district as providing all levels of reading instruction - from remedial to enrichment.) Subjects were randomly drawn from all second through fifth grade children who scored between 85 and 130 on the Peabody Picture Vocabulary test (IQ equivalents). (Mean score for Low Ability Readers = 100; Mean score for High Ability Readers = 107.) Subjects were drawn until 12 high ability upper grade level students (Grades 4 and 5), 12 low ability upper grade level students, 12 high ability primary grade students (Grades 2 and 3), and 12 low ability primary grade students were

selected. Subjects were classified as high ability if they scored 6 months to 2 years above their grade level on both the Wide Range Achievement Test and an informal reading inventory. Subjects were classified as low ability if they scored 6 months to 2 years below their grade level on both the WRAT and IRI.

Materials

In Condition 1, 48 4-letter target words were selected which represented all possible combinations of the experimental word factors (easy/hard decodable words; high/low frequency words; and high/low orthographically redundant words). Easy decodable words had vowels which corresponded to a commonly taught phonic generalization (C$\bar{V}$CE, C$\breve{V}$C, or $\bar{V}$V) and had no consonant digraphs. Hard decodable words had vowels which did not correspond to the above generalizations and/or silent or consonant digraphs. Frequency was determined by the total word frequency count of Carroll, Davies, and Richman (1971). The mean frequency for high frequency words was 1645 per ~5 million, with a range from 111 to 93191. The mean frequency for low frequency words was 34 per ~5 million, with a range from 2 to 88. Orthographic redundancy was based on summed positional frequencies of letters using the norms of Solso and King (1976). The mean summed frequency for redundant words was 71125 per million, with a range from 60753 to 100089. The mean summed frequency for nonredundant words was 35363 per million, with a range from 18208 to 46828. An example of a high frequency, hard decodable, nonredundant word is "soup"; and a high frequency, easy decodable, redundant word is "time".

Apparatus

Visual stimuli were displayed on a back projected screen by means of a carousel projector. Each display was shown by means of a remote control switch which simultaneously initiated a 1/100 second timer. A constant delay of 1 second occurred between the starting of the timer and the visual display. A reaction time device was made which consisted of two keys mounted on a wooden board each of which when depressed stopped the 1/100 second timer.

Procedure

Subjects were tested individually. Each subject sat in front of a table with one hand resting on the RT keyboard. The experimenter randomly chose one of the two conditions.

In the Word/Nonword condition the subjects were instructed to look at the string of letters on the screen and decide if it was a real word or a nonword. A real word was defined as one whose meaning they knew. A nonword was defined as a string of letters which did not mean anything. Before actual testing, subjects practiced depressing the RT keys until the process was automatic. In both the picture and Word/Nonword tasks the sequence of slides were reordered periodically to offset any order effects.

If the picture task was selected, the subject was instructed to read the word on the screen, choose the picture (1 of 2) which represented its meaning, and press the RT key which corresponded to that picture. Prior to the main experiment several practice slides were presented until response was automatic.

Design

Both studies employed a 2^2 between subjects and a 2^3 within subjects design. The factors were factorially combined. The between

subject factors were Grade primary (2, 3) and upper (4, 5) and Ability (High, Low). The within subjects word factors were Decodability (Easy, Hard), Frequency (High, Low), Orthographic Redundancy (Redundant, Nonredundant). There were six replications of each word type (i.e., six easy decodable, high frequency, orthographically redundant words) in the Picture Task. Three of these replications for each word type were randomly selected for the Word/Nonword task. In addition, an equal number of nonwords were used. Half of the nonwords were orthographically legal (e.g., "dila"); half were orthographically illegal (e.g., rglz).

Results and Discussion

The data were analyzed by repeated measures analysis of variance. Only correct responses were analyzed. The error rate was approximately 8%. A significance level of .01 was used. The ANOVA and means for the Picture Task appear in Table 1. The ANOVA and means for the Word/Nonword Task appear in Table 2. Means represent absolute RT's from the instant the stimuli appeared on the screen until the key press.

Picture Task

Both Grade and Ability had significant main effects with older and/or high ability readers having faster RT's. As would be expected, Frequency was significant, with faster RT's for high frequency words. There was a significant interaction between Frequency and Ability. Low Ability readers appear to be exceedingly disadvantaged in identifying or accessing the meaning of low frequency words.

There was a significant main effect of decodability. The meanings of words containing commonly taught phonic units are accessed faster

than words lacking such elements. Apparently young readers decode words into their constituent phonic units before accessing meaning. In other words, they were not using pictorial context plus initial consonants for identification.

There was no main effect of orthography. There was a significant interaction between Orthography and Frequency. Apparently high frequency words are often recognized holistically; whereas low frequency words are decoded. However, low frequency words, which are also low in redundancy, were identified faster than low frequency words, high in redundancy. We would have expected redundancy to have a facilitative effect. Instead, it appears to have a negative, confuseability effect: Words which contain letters that are very common in their respective position within the word resemble other words and thus require more careful (and slower) decoding. A significant interaction between Orthography and Grade further indicated that older readers are most responsive to orthography whereas young readers are relatively insensitive to it. Apparently considerable exposure to print is critical to developing a set for orthography.

Word/Nonword Task

Grade had a significant main effect on RT to decide if a letter string was a real word - older readers being more adept at this task. Ability, however, was not significant at the .01 level (it was at the .05 level). Apparently age and subsequent exposure to print are critical factors in determining "wordness".

Frequency had a significant main effect. High frequency words were more rapidly recognized as real words. However, the magnitude

of this effect is considerably less than in the Picture condition. On the other hand, the magnitude of the significant main effect of decodability is considerably greater than in the picture task. There was also a significant interaction between Frequency and Decodability. Decodability had little impact on high frequency words, again suggesting that such words are frequently processed holistically. However, easy decodable, low frequency words are reacted to considerably faster than hard decodable, low frequency words. Again, we have evidence that such words are being internally decoded. However, we find no significant main effect or interactions with orthography.

General Discussion

Two distinct processes were disclosed in the present experiment. We find a different pattern of significance in the picture task than in the Word/Nonword tasks, and overall, we find faster reaction times in the Word/Nonword tasks. We are sure in the picture task that word meanings were accessed; we are doubtful word meanings were always accessed in the Word/Nonword task. Our instructions to the children in the Word/Nonword task were to decide that a word was a nonword by whether or not they knew its meaning. It appears, however, that children frequently made decisions before accessing meaning. That is, they made decisions about "wordness" based on presemantic characteristics, the most salient of which appeared to be the phonic structures in the word. We may have tapped a prerequisite stage to semantic identification; but this cannot be determined from the present study.

In general it appears that phonic structures are a critical factor in word identification for both good and poor elementary age

readers. It also appears that orthographic redundancy plays a supporting role in the identification of low frequency words. However, only older readers were sensitive to orthographic redundancy. Further, we found the current RT paradigm to be both a reliable and highly useful tool for testing elementary age children.

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Table 1

Significant ANOVA's and Means for Picture Task

Source	F	(Error)	Means
Grade	15.2*	(.527)	
Grade 2, 3			2.80
Grade 4, 5			1.98
Ability	17.5*	(,527)	
High			1.95
Low			2.83
Frequency	117.9*	(.172)	
High			2.08
Low			2.72
Decodability	22.2*	(.135)	
Easy			2.27
Hard			2.52
Orthography x Grade	7.7*	(.085)	
Redundant, Grade 2, 3			2.77
Nonredundant, Grade 2, 3			2.83
Redundant, Grade 4, 5			2.07
Nonredundant, Grade 4, 5			1.89
Frequency x Orthography	15.5*	(.316)	
High Frequency, Redundant			2.04
High Frequency, Nonredundant			2.12
Low Frequency, Redundant			2.85
Low Frequency, Nonredundant			2.60
Frequency x Ability	7.7*	(.172)	
High Frequency, High Ability			1.74
Low Frequency, High Ability			2.18
High Frequency, Low Ability			2.42
Low Frequency, High Ability			3.27

* $p < .01$, $F(1,44)$

Table 2

Significant ANOVA's and Means for Word/Nonword Task

Source	F	(Error)	Means
Grade	16.9*	(.629)	
Grade 2, 3			2.24
Grade 4, 5			1.30
Ability	6.9	(.629)	
High			1.47
Low			2.07
Frequency	11.0*	(.193)	
High			1.52
Low			1.73
Decodability	48.0*	(.160)	
Easy			1.59
Hard			1.99
Frequency x Decodability	12.9*	(5.739)	
High Frequency, Easy			1.43
High Frequency, Hard			1.61
Low Frequency, Easy			1.52
Low Frequency, Hard			2.08

* $p < .01$, $F(1,44)$